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Regular Article

Influence of type cutting, IBA concentration and collection times on rooting of tea (*Camellia sinensis* L.)

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Type of cutting, rooting hormone Indol-3-burtyric acid (IBA), collection time are critical factors that affect rooting development of semi-hardwood cuttings. In this study, the objectives were to determine the best type of cutting, collection times and the effect of IBA (Indol-3-burtyric acid) hormone on rooting of Turkish Tea (*Camellia sinensis* L.) clone (Muradiye-10) cultivars. The cuttings were collected on 15 July and 1 August. After pre-treating with 0, 2000, 4000 and 6000 ppm IBA, the cuttings with full leaf and half leaf cuttings were rooted in perlite medium at the unheated but mist propagated glasshouse. Semi- hardwood cuttings were exposed to the rooting media for 60 days, and then, they all were removed from media to determine the survival rate, rooting rate, root number, root length, root diameter, and root quality. In both years, the survival rates were between 65.0-98.3%; the rooting rates between 10.0-95.0%; the root numbers between 2.2-8.4; the root lengths between 5.9-16.8 cm; the root diameters between 0.60-1.21 mm and the root qualities between 1.56-3.76. The highest rooting and rooting quality were from semi-hardwood cuttings prepared with full leaf cuttings on August 1st. All the cuttings were treated with 4000 and 6000 ppm IBA. The lowest rooting and rooting quality were from control (0 ppm IBA) treatment.

Key Words: Tea, IBA, cutting type, semi-hardwood cutting, rooting

Tea [*Camellia sinensis* (L.) O.Kuntze] is an evergreen shrub that widely cultivated throughout the tropics and subtropics especially in hilly or mountainous regions for its tender leaves that are dried and used for a mildly stimulating beverage (Hodgson *et al*., 1999). Today, tea is one of the most widely used beverages in the world, second only to water and an important cash crop throughout different production areas of the world. Planted area for this plant has reached 3.276 million ha resulting in 4.818.118 ton production in the world. The most important tea producing countries are China, India, Kenya, Sri Lanka, and Turkey (Anon., 2012).

The tea has received considerable interest in recent years as a medicinal agent. Young shoots of tea bushes are mainly processed into black tea, green tea, and oolong tea. Among these, green tea is most beneficial to human health. Recently reported pharmacological properties, e.g., antioxidant, anti-inflammatory, anti-mutagenic, and anti-carcinogenic effects also served to increase the popularity of green tea (Higdon and Frei, 2003; Cabrera *et al*., 2006; Pharn-Huy *et al*., 2008; Yuan *et al*., 2011).

Yield crop of tea is very low in Turkey according to per producing area although it is fifth tea producing country in

the world (Anon., 2013a). Possible causes for lower production are likely insufficient field applications, absence of high quality sapling and other reasons for sapling production and distribution.

In tea gardens of the Turkey, mostly the genetic purity of seeds has not existed because of seed replicated plant seedlings. Generally Chinese varieties have dominated in the gardens and, in addition, many of other types occurred with different forms of morphology, physiology, quality, and yield. Continuing tea production by seed would unavoidably result in new low yielding and quality types (Ayfer *et al.*, 1987a,b; Altındal and Balta, 2002). For these reasons today, tea has been farmed by vegetative propagation (cutting and tissue culture).

Cutting on rooting success has been affected by many factors such as type of plant material, hormone use, collection times, use of shade, rooting mediums and materials structural factors, some chemical treatments, and environmental factors etc. (Ayfer et al., 1987a, b; Günler, 1989; Hartmann *et al*. 2002). In the present study, the aim was to determine the effects of different collection times, the type of cuttings, and the effect of plant growth regulators (IBA) on rooting percentage and quality of a hardly rooting tea clone, Muradiye-10.

Materials and Methods

The research was performed in tea garden and glasshouse of the Rize Atatürk Tea Research Institute of during 2010-2011. In this study, the tea plant material Muradiye-10 clones were used. The garden providing the cuttings was established on a flat field (North: 41° 01', East: 40° 30', Altitude: 106). Soil structure was sandy-loamy. Soil analyses on soil taken in 20 cm below of soil surface were the following:
pH: 4.65-5.35; organic matter : 0.14-3.96%; total nitrogen content: 0.14-0.24; available P_2O_5: 13-30 ppm; exchangeable K_2O: 80-370 ppm

The 20-year-old stud plants for cuttings were pruned in December and cuttings were taken from newly emerged shoots in two different times on 15 July and 1 August respectively. Well-developed disease free cuttings with full-leaf and half-leaf shoots, 3.5 to 4 cm in length were prepared and disinfected by a fungicide (Benlate) against fungus infections. Cuttings, after treated by IBA doses of 0 (control), 2000, 4000, and 6000 ppm were transferred to rooting perlite medium for 60 days. Rooting was performed in unheated glasshouse and the upper part rooting media was shaded by using of porous polyethylene with 70% light transmittance. For rooting, time-dependent automatic mist-propagation system was set at 70-90% level. At the end of rooting period, survival rate (%), rooting rate (%), root number (unit/cutting) quantity), root length (cm), root diameter (mm) and root quality were determined.

Experimental design was a randomized complete block design in a split plot arrangement with three replications, each having 20 cuttings. Data expressed as percentage (rooting rate and survival rate) were transformed using the arc-sin$\sqrt{x}$ transformation, and statistical analyses of transformed data were done by MSTAT-C pocket program (Russell D. Freed, Crop and Soil Sciences Department, Michigan State University). Duncan's Multiple Range Test was used to indicate the differences between the averages. The differences between the level of significance in evaluating the results were explained at 5% as important and 1% as very important.

Results

Experiment carried out in the glasshouse where relative humidity (%) and mean temperature (°C) were recorded during July 15 to October 1 in both years (Fig 1, 2). As shown in Fig 1, 2 mean daily temperatures varied from 18.6 °C to 29.9°C in 2010 and from 12.9 °C to 28.6 °C in 2011. Mean daily relative humidity varied from 61.3% to 88.3% in 2010 and from 62.3% to 89.3% in 2011.

The effect of the treatment (IBA, collection time, type of cutting) on survival, rooting, and root numbers of tea semi

hardwood cutting are summarized in Table 1. In terms of survival rate, significant differences were detected between IBA application (P<0.01), collection time x type of cutting interaction was also found to be significant (P<0.05) fort his parameter in both year. The collection time and type of cutting had significant effect (P<0.01) on survival rate in 2011.

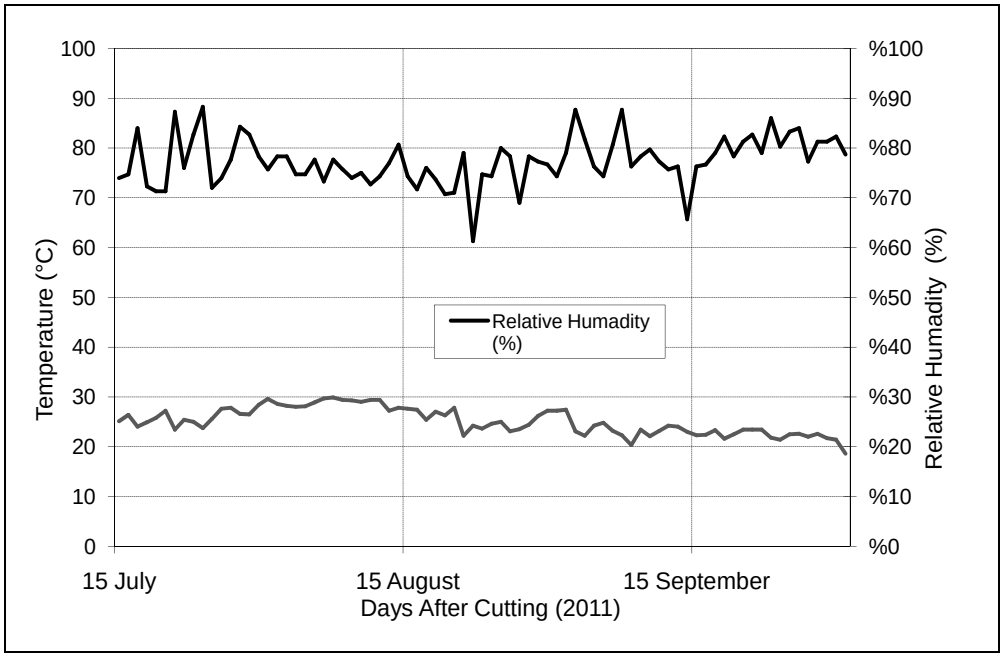

Fig 1. Changing of mean temperature and relative humidity during the days after cutting (2010)

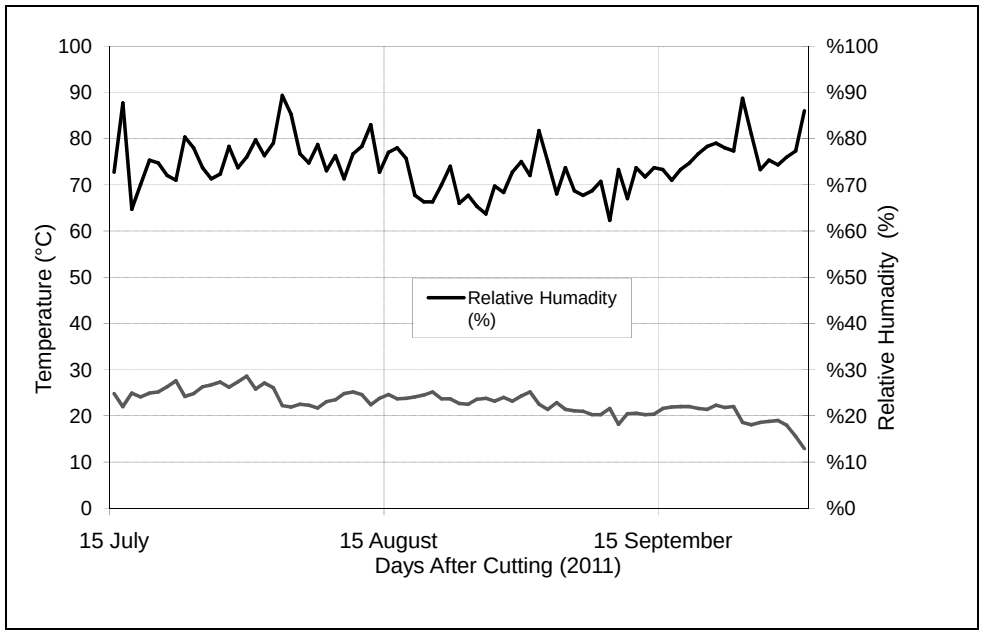

Fig 2. Changing of mean temperature and relative humidity during the days after cutting (2011)

Table 1. Effect of tea cutting of different cutting time, cutting type and IBA dozes cutting survival rate (%), rooting rate (%) and root number (unit/cutting) in Muradiye-10

Year	Cutting Collection Time	Type of Cutting	Survival Rate (%)					Rooting Rate (%)					Root Number (unit / cutting)				
			IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)				
			0	2000	4000	6000	Mean	0	2000	4000	6000	Mean	0	2000	4000	6000	Mean
2010	15 July	Half – Leaf	81.7	86.7	88.3	96.7	88.4 ab	10.0	66.7	68.3	80.0	56.3 b	2.2 d	4.3 bd	3.6 cd	4.1 bd	3.5
		Full – Leaf	90.0	88.3	96.7	91.7	91.7 a	15.0	61.7	81.7	88.3	61.7 b	2.6 d	5.3 ac	5.9 ab	7.1 a	5.2
		Mean	85.9	87.5	92.5	94.2	90.1	12.5	64.2	75.0	84.2	59.0 b**	2.4	4.8	4.8	5.6	4.4 b**
	1 August	Half – Leaf	68.3	95.0	98.3	91.7	88.3 ab	18.3	85.0	95.0	88.3	71.7 a	2.3 d	5.9 ab	6.2 ab	5.5 ac	4.9
		Full – Leaf	65.0	85.0	90.0	91.7	82.9 b	13.3	76.7	78.3	91.7	65.0 b	6.0ab	6.4 ab	5.9 ab	6.2 ab	6.1
		Mean	66.7	90.0	94.2	91.7	85.6	15.8	80.9	86.7	90.0	68.4 a**	4.1	6.1	6.0	5.8	5.5 a**
	Overall Mean	Half – Leaf	75.0	90.9	93.3	94.2	88.4	14.2	75.9	81.7	84.2	64.0	2.2	5.1	4.9	4.8	4.2 b**
	Overall Mean	Full – Leaf	77.5	86.7	93.4	91.7	87.3	14.2	69.2	80.0	90.0	63.4	4.3	5.8	5.9	6.6	5.7 a**
	Overall Mean	IBA	76.3b	88.8 a	93.4 a	93.0 a	87.9	14.2 b	72.6a	80.9 a	87.1 a	63.7	3.3 b	5.5 a	5.4 a	5.7 a	4.9
			$LSD_{1\%}$ (IBA): 9.68 $LSD_{5\%}$ (Cutting Time x Type of Cutting): 7.19					$LSD_{5\%}$ (Cutting Time x Type of Cutting): 7.47 $LSD_{1\%}$ (IBA): 10.05					$LSD_{1\%}$ (IBA): 1.32 $LSD_{5\%}$ (Cutting Time x Type of Cutting x IBA): 1.96				
2011	15 July	Half – Leaf	80.0	83.3	96.7	98.3	89.6	36.7	63.3	83.3	91.7	68.8	3.0	5.4	7.2	7.8	5.8
		Full – Leaf	76.7	81.7	95.0	95.0	87.1	40.0	66.7	88.3	93.3	72.1	3.4	6.1	7.8	8.1	6.3
		Mean	78.4	82.5	95.9	96.7	88.4 b**	38.4 f	65.0d	85.8 b	92.5 a	70.4 a**	3.2	5.7	7.5	7.9	6.1 b*
	1 August	Half – Leaf	76.7	81.7	93.3	91.7	85.9	36.7	55.0	76.7	83.3	62.9	3.2	5.7	7.3	8.0	6.0
		Full – Leaf	75.0	80.0	90.0	90.0	83.8	31.7	53.3	80.0	81.7	61.7	3.5	6.2	8.3	8.4	6.6
		Mean	75.9	80.9	91.7	90.9	84.8 a**	34.2 f	54.0e	78.4 c	82.5 bc	62.3 b**	3.3	6.0	7.8	8.2	6.3 a*
	Overall Mean	Half – Leaf	78.4cd	82.5 c	95.0 a	95.0 a	87.7 a**	36.7	59.2	80.0	87.5	65.9	3.1	5.6	7.3	7.9	5.9 b**
	Overall Mean	Full – Leaf	75.9d	80.9 cd	92.5 b	92.5 b	85.4 b**	35.9	60.0	84.2	87.5	66.9	3.4	6.1	8.0	8.2	6.5 a**
	Overall Mean	IBA	77.2b	81.7 b	93.7 a	93.7 a	86.6	36.3 d	59.6c	82.1 a	87.5 b	66.4	3.3 d	5.9 c	7.7 b	8.1 a	6.2
			$LSD_{1\%}$ (IBA): 3.50, $LSD_{5\%}$ (Type of Cutting x IBA): 3.68					$LSD_{1\%}$ (IBA): 2.93, $LSD_{5\%}$ (Cutting Time x IBA): 3.08					$LSD_{1\%}$ (IBA): 0.29				

* Values not associated with the same letter are significantly different (P<.005) ** Values not associated with the same letter are significantly different (P<.001)

Table 2. Effect of tea cutting of different cutting time, cutting type and IBA dozes the longest root length (cm) and diameter (mm) and root quality (0-4 poin) in Muradiye-10

Year	Cutting Collection Time	Type of Cutting	Root Length (cm)					Root Diameter (mm)					Root Quality (0-4 points)				
			IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)				
			0	2000	4000	6000	Mean	0	2000	4000	6000	Mean	0	2000	4000	6000	Mean
2010	15 July	Half – Leaf	5.9	12.3	9.2	8.9	9.1	0.60	0.90	0.79	0.73	0.75	1.56	2.38	2.96	2.65	2.37
		Full – Leaf	7.0	15.1	15.4	13.3	12.7	0.68	0.92	0.90	0.83	0.83	1.58	3.52	3.52	3.47	3.02
		Mean	6.4	13.7	12.3	11.1	10.9 b**	0.64 d	0.91 bc	0.84 bc	0.78 cd	0.79 b**	1.57	2.95	3.24	3.06	2.71 b**
	1 August	Half – Leaf	10.0	15.1	13.8	13.3	13.0	1.21	0.91	0.93	0.95	1.00	1.81	3.37	3.43	3.70	3.08
		Full – Leaf	11.4	16.2	15.5	15.0	14.5	0.98	1.04	1.03	0.93	1.00	2.92	3.58	3.40	3.68	3.40
		Mean	10.7	15.6	14.6	14.2	13.8 a**	1.10 a	0.98 ab	0.98 ab	0.94 ac	1.00 a**	2.36	3.48	3.42	3.69	3.24 a**
	Overall Mean	Half – Leaf	7.9	13.7	11.5	11.1	11.1 b**	0.91	0.91	0.86	0.84	0.88	1.68	2.88	3.20	3.17	2.73 b**
	Overall Mean	Full – Leaf	9.2	15.6	15.4	14.2	13.6 a**	0.83	0.98	0.96	0.88	0.91	2.25	3.55	3.46	3.58	3.21 a**
	Overall Mean	IBA	8.6 b	14.7 a	13.5 a	12.6 a	12.4	0.87	0.94	0.91	0.86	0.90	1.97 b	3.21 a	3.33 a	3.38 a	2.97
			$LSD_{1\%}$ (IBA): 2.95					$LSD_{1\%}$ (Cutting Time x IBA): 0.17					$LSD_{1\%}$ (IBA): 0.63				
2011	15 July	Half – Leaf	7.9	12.7	14.9	14.9	12.6	0.79	0.86	0.96	1.02	0.91	2.25	2.61	3.44	3.37	2.92
		Full – Leaf	8.3	14.7	15.9	16.3	13.8	0.82	0.91	1.07	1.08	0.97	2.42	2.8	3.57	3.68	3.12
		Mean	8.1	13.7	15.4	15.6	13.2 b**	0.80 b	0.89 b	1.02 a	1.05 a	0.94 b**	2.34	2.70	3.51	3.53	3.02 b*
	1 August	Half – Leaf	8.5	14.2	16.4	16.4	13.8	1.08	1.00	1.02	1.07	1.05	2.33	2.72	3.59	3.50	3.04
		Full – Leaf	8.9	14.4	16.7	16.8	14.2	1.08	1.05	1.14	1.17	1.11	2.46	3.15	3.70	3.76	3.27
		Mean	8.7	14.3	16.5	16.6	14.0 a**	1.08 a	1.03 a	1.08 a	1.12 a	1.08 a**	2.39	2.93	3.64	3.63	3.15 a*
	Overall Mean	Half – Leaf	8.2	13.4	15.6	15.6	13.2 b**	0.94	0.93	0.99	1.05	1.00	2.29	2.66	3.51	3.44	2.98 b**
	Overall Mean	Full – Leaf	8.6	14.5	16.3	16.5	14.0 a**	0.95	0.98	1.10	1.12	1.04	2.44	2.97	3.64	3.72	3.19 a**
	Overall Mean	IBA	8.4 c	14.0 b	16.0 a	16.1 a	13.6	0.94 b	0.96 b	1.05 a	1.05 a	1.02	2.37 c	2.82 b	3.58 a	3.58 a	3.09
			$LSD_{1\%}$ (IBA): 0.89					$LSD_{5\%}$ (IBA): 0.08, $LSD_{1\%}$ (Cutting Time x IBA): 0.12					$LSD_{\%1}$ (IBA): 0.23				

* Values not associated with the same letter are significantly different (P<.005) ** Values not associated with the same letter are significantly different (P<.001)

Other applications had insignificant effect in both years. The survival rate varied from 65.0% to 96.7% in 2010 and from 75.0% to 98.3 % in 2011. The best results in every two years for collection time (90.1%, 88.4% respectively) were on July 15; for type of cuttings were half leaf cuttings (88.4%, 87.7% respectively); for IBA treatments were 4000 ppm IBA applications (93.4%, 91.7% respectively).

The rooting rate was very significant effect (P<0.01) applications of IBA and collection time (every two years), triple interaction (in 2010) and collection time x IBA applications (in 2011) significant effect (P<0.05). Rooting rate varied from 10.0% to 95.0% in 2010 and from 31.7% to 93.3% in 2011. The best results were taken in August 1, 4000 ppm IBA doses based on the half leaf cuttings. The control group had the lowest results for cuttings.

When looked at the impact on the root number of applications in 2010, collection time, type of cutting, and IBA applications had a significant effect (P<0.01), triple interaction had a significant effect (P<0.05). In 2011, the IBA applications and type of cutting had a significant effect (P<0.01), cutting time had a significant effect (P<0.05). The number of root varied from 2.2 to 7.1 units in 2010 and from 3.0 to 8.4 units in 2011. The best results in 2010 and 2011 (7.1 units and 8.4 units, respectively) taken on 15 July 2010, 1 August 2011 and 6000 ppm IBA treatment based on the full leaf cuttings were prepared.

The results of root length (cm), root diameter (mm) and the root quality (0-4 points) were in Table 2. Based on these results over, the root length in two years, doses of IBA, type of cutting and collection time was very significant (P<0.01) effect. The root lengths varied from 5.9 to 16.2 cm in 2010 and from 7.9 to 16.8 cm in 2011. The best results (16.2 cm and 16.8 cm respectively) were taken from the full leaf cuttings prepared on August 1, in 2010 2000 ppm, in 2011 6000 ppm IBA application.

On the root diameter in 2010, collection time and collection time x IBA of applications were very important effect (P<0.01); in 2011, collection time and collection time x IBA of applications were very important effect (P<0.01), IBA of application was important effect (P<0.05). The diameters varied from 0.60 mm to 1.21 mm in 2010 and from 0.79 mm to 1.17 mm in 2011. The best result in 2010 (1.21 mm), taken on 1 August, prepared the half leaf cuttings, 0 ppm (control) IBA has been application. The best result in 2011 (1.17 mm), taken on 1 August prepared the full leaf cuttings, 4000 ppm IBA has been application.

Analyzed data on the root quality in 2010, the cutting type and collection time and IBA applications were very important effect (P<0.01); in 2011, the IBA application and type of cutting was very significant effect (P<0.01), collection time was significant effect (P<0.05). The quality of the root varied from 1.56 to 3.70 in 2010; from 2.25 to 3.76 in 2011. The best result in every two years taken on August 1 and 6000 ppm IBA treatment based on the full leaf cutting were prepared.

Discussion

According to the results of temperature and relative humidity values were compatible with those reported previously (Anon., 2013b).

As a result of all these findings, among all parameters the best type of cutting was full leaf cutting, 4000 and 6000 ppm IBA was the most appropriate dose. Survival and rooting rate parameters on July 15 was the most suitable time for collection time, for the other parameters August 1 was determined. Indeed, Weaver (1972) stated that growth regulators changed the number and the type of root and IBA was a manufacturer of the strong fringe root. Researchers, who studied the cutting reproduction of tea and other fruit (Ayfer *et al.*, 1987a; Üçler *et al.*, 2004; Zenginbal and Özcan, 2013; Zenginbal and Özcan, 2014) obtained similar results.

In terms of collection time, rooting was better on 1 August. Kinez (1967), in a tea propagation study by cutting in Rize, cuttings taken in the beginning and in the middle of August resulted in higher results. Eliadze *et al*. (1978), tea cuttings taken during June to October, and vitality and rooting rate of cuttings increased from June to August, and then decreased Also Gabrichidze *et al.* (1976) in their study cutting taken in April, August and October. The cuttings taken in August compared with April, October due to the low N and high sugar levels in August described as were the best cutting time in terms of rooting and root number.

In terms of type of cutting in cutting to the full-leaf cutting had better results than a half-leaf cuttings. In cutting the leaves and buds, prepared had a positive effect on the number of root and root formation, Hartmann *et al*. (2002), the presence of leaf cuttings physiological and morphological report of activities carried out more quickly. In addition, Zenginbal and Özcan (2014), the presence of a full-leaf kiwifruit cuttings rooting and root state that has a positive impact in terms of number.

Due to the simplicity, the tea plant is reproduced by seeds traditionally. However, in recent years, high-efficiency and high-quality tea clones has been selected all over the world, and have given great importance to cutting propagation applications.

Conclution

This study was conducted with for standard varieties, which is an important step to increase the yield and quality in this study for the production of seedlings, propagated the possibilities of usage tea cutting; cutting time, cutting type and different applications of growth regulators effects on rooting percentage and root quality were determined.

As a result of this study, rooting of tea clones cuttings for rooting in order to ensure a successful, good selection of cuttings and appropriate conditions must necessary. Therefore misting and shading systems unit cutting should be rooting under system with. In addition, tea cuttings on August 1, as a single full leaf should be prepared and 4000 - 6000 ppm IBA should be applied. Perlite is used then as the rooting environment.

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